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DECLARATION

I, Koichi OISHI Patent Attorney, of OISHI & PARTNERS, 4th Floor, Kanda-ON Building, 1-10, Kandasudacho, Chiyoda-ku, Tokyo 101-0041 Japan, hereby certify that I am the translator of the certified official copy of the documents in respect of an application for a Patent filed in Japan on September 9, 2002 under Patent Application No. 2002-262711 and that the following is a true and correct translation to the best of my knowledge and belief.

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[TITLE OF THE INVENTION]

A METHOD FOR RECORDING INFORMATION IN AN OPTICAL RECORDING MEDIUM, AN APPARATUS FOR RECORDING INFORMATION IN AN OPTICAL RECORDING MEDIUM AND AN OPTICAL RECORDING MEDIUM

[CLAIMS]

[Claim 1] A method for recording information in a write-once type optical recording medium, the method for recording information in a write-once type optical recording medium comprising a step of setting a pulse pattern of a power level of a laser beam to be projected for forming a first recording mark based on at least one of a length of a blank region to be formed immediately after the formation of the first recording mark and a length of a second recording mark to be formed subsequent to the formation of the first recording mark.

[Claim 2] A method for recording information in a write-once type optical recording medium in accordance with Claim 1, wherein the first recording mark is the shortest recording mark.

[Claim 3] A method for recording information in a write-once type optical recording medium in accordance with Claim 1 or 2, wherein the pulse pattern of the power level of a laser beam is set depending upon a length of a blank region formed immediately before the formation of the first recording mark.

[Claim 4] A method for recording information in a write-once type

optical recording medium, the method for recording information in a write-once type optical recording medium comprising a step of setting a time period between a fall time of a power level of a laser beam to be projected for forming a first recording mark and a fall time of a data pulse corresponding to the first recording mark based on at least one of a length of the first recording mark, a length of a blank region to be formed immediately after the formation of the first recording mark and a length of a second recording mark to be formed subsequent to the formation of the first recording mark.

[Claim 5] A method for recording information in a write-once type optical recording medium in accordance with Claim 4, wherein in the case where x is the length of the first recording mark, y is the length of the blank region to be formed immediately after the formation of the first recording mark and z is the length of the second recording mark to be formed subsequent to the formation of the first recording mark, a time period T3 (x, y, z) from the fall time of a data pulse corresponding to the first recording mark to the fall time of the power level of the laser beam to be projected for forming the first recording mark is set so as to satisfy a formula below, where $x1$ is smaller than $x2$.

$$T3\ (x1, y, z) > T3\ (x2, y, z)$$

[Claim 6] A method for recording information in a write-once type optical recording medium in accordance with Claim 4 or 5, wherein in the case where x is the length of the first recording mark, y is the length of the blank region to be formed immediately after the formation of the first recording mark and z is the length of the second recording mark to be formed subsequent to the formation of the first recording mark, the time

period T3 (x, y, z) from the fall time of a data pulse corresponding to the first recording mark to the fall time of the power level of the laser beam to be projected for forming the first recording mark is set so as to satisfy a formula below, wherein $y1$ is smaller than $y2$.

$$T3\ (x,\ y1,\ z) > T3\ (x,\ y2,\ z)$$

[Claim 7] A method for recording information in a write-once type optical recording medium in accordance with any one of Claims 4 to 6, wherein in the case where x is the length of the first recording mark, y is the length of the blank region to be formed immediately after the formation of the first recording mark and z is the length of the second recording mark to be formed subsequent to the formation of the first recording mark, the time period T3 (x, y, z) from the fall time of a data pulse corresponding to the first recording mark to the fall time of the power level of the laser beam to be projected for forming the first recording mark is set so as to satisfy a formula below, where $z1$ is smaller than $z2$.

$$T3\ (x,\ y,\ z1) > T3\ (x,\ y,\ z2)$$

[Claim 8] A method for recording data in an optical recording medium in accordance with any one of Claims 4 to 7, wherein in the case where x is the length of the first recording mark, y is the length of the blank region to be formed immediately after the formation of the first recording mark and z is the length of the second recording mark to be formed subsequent to the formation of the first recording mark, a value T3' (x, y, z : VL) obtained by normalizing the time period T3 from the fall time of a data pulse corresponding to the first recording mark to the fall time of the power level of the laser beam to be projected for forming the

first recording mark at a linear recording velocity VL with a channel bit period and a value T3'(x, y, z : VH) obtained by normalizing the time period T3 from the fall time of a data pulse corresponding to the first recording mark to the fall time of the power level of the laser beam to be projected for forming the first recording mark at a linear recording velocity VH higher than the linear recording velocity VL with a channel bit period are set so as to satisfy a following formula.

$$T3'(x, y, z : VL) < T3'(x, y, z : VH)$$

[Claim 9] A method for recording data in an optical recording medium in accordance with any one of Claims 4 to 8, wherein a time period from a rise time of a data pulse corresponding to the first recording mark to a rise time of the power level of the laser beam to be projected for forming the first recording mark is set based on at least one of the length of a blank region formed immediately before the formation of the first recording mark and the length of the first recording mark.

[Claim 10] A method for recording data in an optical recording medium in accordance with Claim 9, wherein in the case where a is the length of the blank region formed immediately before the formation of the first recording mark and b is the length of the first recording mark, a time period T1 (a, b) from the rise time of a data pulse corresponding to the first recording mark to the rise time of the power level of the laser beam to be projected for forming the first recording mark is set so as to satisfy a formula below, where $a1$ is smaller than $a2$.

$$T1\ (a1, b) > T3\ (a2, b)$$

[Claim 11] A method for recording data in an optical recording

medium in accordance with Claim 9 or 10, wherein in the case where *a* is the length of the blank region formed immediately before the formation of the first recording mark and *b* is the length of the first recording mark, a time period T1 (*a*, *b*) from the rise time of a data pulse corresponding to the first recording mark to the rise time of the power level of the laser beam to be projected for forming the first recording mark is set so as to satisfy a formula below, where *b1* is smaller than *b2*.

T1 (*a*, *b1*) < T3 (*a*, *b2*)

[Claim 12] A method for recording data in an optical recording medium in accordance with any one of Claims 1 to 11, wherein a recording layer of the write-once type optical recording medium contains an organic dye.

[Claim 13] An apparatus for recording information in a write-once type optical recording medium, the apparatus for recording information in a write-once type optical recording medium being constituted so that a pulse pattern of a power level of a laser beam to be projected for forming a first recording mark is set based on at least one of a length of a blank region to be formed immediately after the formation of the first recording mark and a length of a second recording mark to be formed subsequent to the formation of the first recording mark.

[Claim 14] A write-once type optical recording medium comprising setting information necessary for setting a pulse pattern of a power level of a laser beam to be projected for forming a first recording mark based on at least one of a length of a blank region to be formed immediately after the formation of the first recording mark and a length of a second

recording mark to be formed subsequent to the formation of the first recording mark.

[Claim 15] A write-once type optical recording medium in accordance with Claim 14, which further comprises a recording layer containing an organic dye.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[FIELD OF THE INVENTION]

The present invention relates to a method for recording information in an optical recording medium, and particularly, to a method for recording information in a write-once type optical recording medium. Further, the present invention relates to an apparatus for recording information in an optical recording medium, and particularly, to an apparatus capable for recording information in a write-once type optical recording medium. Furthermore, the present invention relates to an optical recording medium, and particularly, to a write-once type optical recording medium.

[0002]

[DESCRIPTION OF THE PRIOR ART]

Optical recording media such as the CD, DVD and the like have been widely used as recording media for recording digital data. These optical recording media can be roughly classified into optical recording media such as the CD-ROM and the DVD-ROM that do not enable writing and rewriting of data (ROM type optical recording media), optical recording media such as the CD-R and DVD-R that enable writing but not rewriting of data (write-once type optical recording media), and

optical recording media such as the CD-RW and DVD-RW that enable rewriting of data (data rewritable type optical recording media).

[0003]

As well known in the art, data are generally recorded in a ROM type optical recording medium using pre-pits formed in a substrate in the manufacturing process thereof, while in a data rewritable type optical recording medium a phase change material is generally used as the material of the recording layer and data are recorded utilizing changes in an optical characteristic caused by phase change of the phase change material.

[0004]

On the other hand, in a write-once type optical recording medium, an organic dye such as a cyanine system dye, phthalocyanine system dye or azo dye is generally used as the material of the recording layer and data are recorded utilizing changes in an optical characteristic caused by irreversible chemical change of the organic dye (sometimes physical change in addition to the irreversible chemical change of the organic dye). The irreversible chemical change of the organic dye is caused by projecting a laser beam having a power higher than a predetermined power onto the write-once type optical recording medium, whereby a desired recording mark is formed therein.)

[0005]

Concretely, when data are to be recorded in a write-once type optical recording medium, it is general that the power of a laser beam is set to a sufficiently high recording power (*Pw*) when the laser beam is to be projected onto a region where a recording mark is to be formed and that the power level of the laser beam is set to a sufficiently low bottom power (*Pb*) when the laser beam is to be projected onto a region where no

recording mark is to be formed, namely, a blank region, thereby projecting the laser beam onto the recording layer of the write-once type optical recording medium. As a result, in the region onto which the laser beam whose power is set to the recording power (*Pw*) is projected, the organic dye contained in the region of the recording layer is decomposed and transformed, thereby forming a recording mark. On the other hand, in the region onto which the laser beam whose power is set to the bottom power (*Pb*) is projected, the decomposition and transformation of the organic dye contained in the recording layer does not occur, so that a blank region is formed. Thus, data can be recorded in a write-once type optical recording medium by modulating the power of the laser beam to be projected onto the optical recording medium in this manner while the optical recording medium is being rotated.

[0006]

[PROBLEMS TO BE SOLVED BY THE INVENTION]

However, since heat generated in the recording layer by being irradiated with the laser beam is quickly transferred from the region onto which the laser beam is projected to ambient regions within the recording layer, even in regions other than the region onto which the laser beam whose power is set to the recording power (*Pw*) is projected, the organic dye contained therein sometimes is decomposed and transformed and on the other hand, in the region onto which the laser beam whose power is set to the recording power (*Pw*) is projected, deformation of the substrate sometimes fails to occur. Therefore, in the case where data are recorded in the recording layer using a simple pulse train pattern determined so that the power of the laser beam to be projected onto a region where a recording mark is to be formed is set to the recording power (*Pw*) and that the power of the laser beam to be

projected onto a blank region where no recording mark is to be formed is set to the bottom power (*Pb*), the shape of a recording mark formed in the recording layer sometimes becomes inappropriate so that a reproduced signal having good signal characteristics cannot be obtained.

[0007]

These problems become prominent as the linear recording velocity becomes higher and in the case of recording data in a DVD-R in which data are normally recorded at a linear recording velocity of about 3.5 m/sec at a linear recording velocity higher than 2 x speed or a linear recording velocity higher than 4 x speed, these problems become particularly prominent.

[0008]

Further, although these problems are particularly serious in a write-once type optical recording medium having a recording layer containing an organic dye, the same problems occur not only in a write-once type optical recording medium having a recording layer containing an organic dye but also in other kinds of a write-once type optical recording medium such as that having a recording layer consisting of a plurality of layered inorganic films.

[0009]

It is therefore an object of the present invention is to provide a method for recording information in a write-once type optical recording medium, which is suitable for recording data in a write-once type optical recording medium at a high linear recording velocity.

[0010]

It is another object of the present invention is to provide an apparatus for recording information in a write-once type optical recording medium, which can record data in a write-once type optical

recording medium at a high linear recording velocity.

[0011]

It is a further object of the present invention is to provide a write-once type optical recording medium in which data can be recorded at a high linear recording velocity.

[0012]

[MEANS FOR SOLVING THE PROBLEMS]

The inventors of the present invention vigorously pursued a study for enabling a recording mark having a good shape to be formed even when data are to be recorded at a high linear recording velocity and, as a result, made the discovery that the shape of a recording mark was influenced by the length of a blank region to be formed immediately after the formation of the recording mark and the length of a next recording mark to be formed subsequent to the formation of the recording mark. It is reasonable to assume that this is because heat generated in a recording layer by the laser beam projected thereonto for forming the next recording mark is transferred to the recording mark, thereby influencing the shape of the recording mark, particularly, the position of the rear edge portion thereof.

[0013]

The present invention is based on these findings and in one aspect of the present invention, a method for recording information is adapted for recording information in a write-once type optical recording medium and is characterized by comprising a step of setting a pulse pattern of a power level of a laser beam to be projected for forming a first recording mark based on at least one of a length of a blank region to be formed immediately after the formation of the first recording mark and a length of a second recording mark to be formed subsequent to the formation of

the first recording mark.

[0014]

According to this aspect of the present invention, since a pulse pattern of a power level of a laser beam to be projected for forming a first recording mark is set based on at least one of a length of a blank region to be formed immediately after the formation of the first recording mark and a length of a second recording mark to be formed subsequent to the formation of the first recording mark, the pulse pattern is determined in accordance with the length of a blank region to be formed immediately after the formation of the first recording mark and the length of a second recording mark to be formed subsequent to the formation of the first recording mark. Therefore, since a recording mark having an appropriate length and a blank region having an appropriate length can be formed even when data are to be recorded at a high linear recording velocity, it is possible to reproduce a signal having good signal characteristics.

[0015]

Since it is general that as a recording mark to be formed is shorter, it is liable to be influenced by the length of a blank region to be formed immediately after the formation of the first recording mark and the length of a second recording mark to be formed subsequent to the formation of the first recording mark, it is preferable for the first recording mark to be the shortest recording mark.

[0016]

Further, since the shape of a recording mark is influenced by the length of a blank region immediately before the formation of the recording mark, it is more preferable for the pulse pattern to be determined by taking into account the length of the length of a blank region immediately before the formation of the recording mark in

addition to the length of a blank region to be formed immediately after the formation of the first recording mark and the length of a second recording mark to be formed subsequent to the formation of the first recording mark. In the case where the pulse pattern is determined in this manner, since the pulse pattern is determined by taking into account the influence of heat generated in a recording layer by the laser beam projected thereonto for forming a preceding recording mark and a subsequent recording mark, it is possible to form a recording mark having a more appropriate length and a blank region having a more appropriate length.

[0017]

In another aspect of the present invention, a method for recording information is adapted for recording information in a write-once type optical recording medium and is characterized by comprising a step of setting a time period between a fall time of the power level of a laser beam to be projected for forming a first recording mark and a fall time of a data pulse corresponding to the first recording mark is set based on at least one of a length of the first recording mark, a length of a blank region to be formed immediately after the formation of the first recording mark and a length of a second recording mark to be formed subsequent to the formation of the first recording mark. According to this aspect of the present invention, it is possible to control the position of the rear edge portion of a recording mark in a desired manner.

[0018]

Assuming that x is the length of the first recording mark, y is the length of the blank region to be formed immediately after the formation of the first recording mark, z is the length of the second recording mark to be formed subsequent to the formation of the first recording mark and

T3 (x, y, z) is a time period from the fall time of a data pulse corresponding to the first recording mark to the fall time of the power level of the laser beam to be projected for forming the first recording mark, in the case where $x1$ is smaller than $x2$, it is preferable for the time period T3 (x, y, z) to be set so as to satisfy the formula: T3 ($x1$, y, z) > T3 ($x2$, y, z), in the case where $y1$ is smaller than $y2$, it is preferable for the time period T3 (x, y, z) to be set so as to satisfy the formula: T3 (x, $y1$, z) > T3 (x, $y2$, z) and in the case where $z1$ is smaller than $z2$, it is preferable for the time period T3 (x, y, z) to be set so as to satisfy the formula: T3 (x, y, $z1$) > T3 (x, y, $z2$). In the case where the time period T3 (x, y, z) is set so as to satisfy the above mentioned formulae, it is possible to effectively prevent the rear edge portion of the first recording mark from extending forward.

[0019]

Further, in the case where T3' (x, y, z : VL) is a value obtained by normalizing the time period T3 from the fall time of a data pulse corresponding to the first recording mark to the fall time of the power level of the laser beam to be projected for forming the first recording mark at a linear recording velocity VL with a channel bit period and T3'(x, y, z : VH) is a value obtained by normalizing the time period T3 from the fall time of a data pulse corresponding to the first recording mark to the fall time of the power level of the laser beam to be projected for forming the first recording mark at a linear recording velocity VH higher than the linear recording velocity VL with a channel bit period, it is preferable for T3' (x, y, z : VL) and T3'(x, y, z : VH) to be set so as to satisfy the formula: T3'(x, y, z : VL) < T3'(x, y, z : VH). In the case where T3' (x, y, z : VL) and T3'(x, y, z : VH) are set so as to satisfy the formula: T3'(x, y, z : VL) < T3'(x, y, z : VH), it is possible to prevent the rear edge

portion of the first recording mark from extending forward even when data are to be recorded at a high linear recording velocity.

[0020]

Furthermore, it is preferable for a time period from a rise time of a data pulse corresponding to the first recording mark to a rise time of the power level of the laser beam to be projected for forming the first recording mark to be set based on at least one of the length of a blank region formed immediately before the formation of the first recording mark and the length of the first recording mark. In the case where the time period from a rise time of a data pulse corresponding to the first recording mark to a rise time of the power level of the laser beam to be projected for forming the first recording mark is set in this manner, it is possible to control the position of the rear edge portion of a recording mark in a desired manner.

[0021]

Moreover, assuming that a is the length of the blank region formed immediately before the formation of the first recording mark, b is the length of the first recording mark and T1 (a, b) is a time period from the rise time of a data pulse corresponding to the first recording mark to the rise time of the power level of the laser beam to be projected for forming the first recording mark, in the case where $a1$ is smaller than $a2$, it is preferable for T1 (a, b) to be set so as to satisfy a formula: T1 ($a1$, b) > T3 ($a2$, b) and in the case where $b1$ is smaller than $b2$, it is preferable for T1 (a, b) to be set so as to satisfy a formula: T1 (a, $b1$) < T3 (a, $b2$). In the case where T1 (a, b) is set so as to satisfy the above mentioned formulae, it is possible to effectively prevent the rear edge portion of the first recording mark from extending forward.

[0022]

Further, it is preferable for a write-once type optical recording medium to which the information recording method according to the present invention is applied to include a recording layer containing an organic dye.

[0023]

Furthermore, an information recording according to the present invention is adapted for recording information in a write-once type optical recording medium and is characterized by being constituted so that a pulse pattern of a power level of a laser beam to be projected for forming a first recording mark is set based on at least one of a length of a blank region to be formed immediately after the formation of the first recording mark and a length of a second recording mark to be formed subsequent to the formation of the first recording mark.

[0024]

Further, it is preferable for a write-once type optical recording medium in which the information is recorded using the information recording apparatus according to the present invention to include a recording layer containing an organic dye.

[0025]

Furthermore, an optical recording medium according to the present invention is constituted as a write-once type optical recording medium and is characterized by comprising setting information necessary for setting a pulse pattern of a power level of a laser beam to be projected for forming a first recording mark based on at least one of a length of a blank region to be formed immediately after the formation of the first recording mark and a length of a second recording mark to be formed subsequent to the formation of the first recording mark.

[0026]

Moreover, it is preferable for the optical recording medium according to the present invention to include a recording layer containing an organic dye.

[0027]

[DESCRIPTION OF THE PREFERRED EMBODIMENTS]

Hereinafter, a preferred embodiment of the present invention will now be explained in detail with reference to accompanying drawings.

[0028]

Figure 1 (a) is a schematic partially cutaway perspective view showing an optical recording medium that is a preferred embodiment of the present invention and Figure 1 (b) is an enlarged schematic cross-sectional view of the part of the optical recording medium indicated by A in Figure 1 (a).

[0029]

An optical recording medium 10 shown in Figures 1 (a) and (b) is constituted as a write-once type optical recording medium of a DVD-R type and has an outer diameter of about 120 mm and a thickness of about 1.2 mm. As shown in Figure 1 (b), the optical recording medium 10 includes a light transmissible substrate 11 and a dummy substrate 12, and a recording layer 21, a reflective layer 22, a protective layer 23 and an adhesion layer 24 formed between the light transmissible substrate 11 and the dummy substrate 12.

[0030]

The light transmissible substrate 11 is a disk-like substrate formed of a material having sufficiently high light transmittance with respect to light in the wavelength region of the laser beam. One of the major surfaces of the light transmissible substrate 11 constitutes a light incidence plane 11a through which the laser enters and grooves (not

shown) and lands (not shown) for guiding the laser beam are spirally formed on the surface of the other major surface thereof from a portion in the vicinity of the center thereof toward the outer peripheral portion thereof. The light transmissible substrate 11 is a layer through which the laser beam passes when data are to be recorded in the recording layer 21 described later or when data recorded in the recording layer 21 are to be reproduced and serves as a support for ensuring mechanical strength required for the optical recording medium 10. The light transmissible substrate 11 has a thickness of about 0.6 mm and can be formed of various materials. The light transmissible substrate 11 can be formed of glass, ceramic, resin or the like, for example. Among these, resin is preferably used for forming the light transmissible substrate 11 since resin can be easily shaped. Illustrative examples of resins suitable for forming the light transmissible substrate 11 include polycarbonate resin, acrylic resin, epoxy resin, polystyrene resin, polyethylene resin, polypropylene resin, silicone resin, fluoropolymers, acrylonitrile butadiene styrene resin, urethane resin and the like. Among these, polycarbonate resin is most preferably used for forming the substrate 11 from the viewpoint of easy processing, optical characteristics and the like.

[0031]

The dummy substrate 12 is a disc-like substrate used for ensuring that the optical recording medium 10 has a thickness of about 1.2 mm and is formed so as to have a thickness of about 0. 6 mm, similarly to the light transmissible substrate 11. The dummy substrate 12 can be formed of glass, ceramic, resin or the like, similarly to the light transmissible substrate 11. In this embodiment, since the laser beam is projected onto the recording layer 21 via the light transmissible substrate 11 located

opposite to the dummy substrate 12, it is not necessary for the dummy substrate 12 to have a light transmissible property. Nevertheless, it is preferable to form the dummy substrate 12 of polycarbonate resin from the viewpoint of easy processing.

[0032]

The recording layer 21 contains an organic dye such as a cyanine system dye, a merocyanine system dye, a methine system dye, a derivative of such a dye, a benzenethiol metal complex, a phthalocyanine dye, a naphthalocyanine dye, an azo dye or the like and is formed by coating the surface of the light transmissible substrate 11 on which the grooves and the lands are formed with the above mentioned organic dye. When a laser beam whose power is set to be equal to or higher than a predetermined level is projected onto the recording layer 21, the organic dye contained in the region of the recording layer 21 irradiated with the laser beam is decomposed and transformed, whereby optical characteristics of the region irradiated with the laser beam are changed. a region in which an organic dye contained in a recording layer 21 is decomposed and transformed is used as a recording mark and a region in which an organic dye contained in a recording layer 21 is not decomposed and transformed is used as a blank region. Data to be recorded are expressed by the length of a recording mark (the length between the front edge portion and the rear edge portion of the recording mark) and the length of the blank region (the length between the rear edge portion of the recording mark and the front edge portion of a following recording mark). Each of the recording mark and the blank region is formed so as to have a length of an integral multiple of T, where T is a length corresponding to one period of a clock used as a reference. Concretely, in the case where the 8/16 modulation Code is employed as a data

modulation code as in a DVD-R, each of the recording mark and the blank region is formed so as to have a length of any one of 3T to 11T and 14T.

[0033]

The reflective layer 22 is a thin layer for reflecting the laser beam projected onto the optical recording medium 10 when data recorded therein are to be reproduced and passing through the light transmissible substrate 11 and the recording layer 21 and is formed on the surface of the recording layer 21. The material for forming the reflective layer 21 is not particularly limited insofar as it can reflect the laser beam and the reflective layer 21 can be formed of Mg, Al, Ti, Cr, Fe, Co, Ni, Cu, Zn, Ge, Ag, Pt, Au or the like. Among these, a metal material such as Al, Au, Ag and Cu or an alloy containing at least one of these metals such as an alloy of Ag and Cu is preferably used for forming the reflective layer 22 because it has high reflective coefficient.

[0034]

The protective layer 23 is a layer for protecting the recording layer 21 and the reflective layer 22 formed on the light transmissible substrate 11 and is formed so as to cover the reflective layer 22. The material for forming the protective layer 23 is not particularly limited insofar as it can physically or chemically protect the recording layer 21 and the reflective layer 22 but it is preferable to form the protective layer 23 of ultraviolet ray curable resin.

[0035]

The adhesion layer 24 is a layer for adhering a multi-layered unit consisting of the light transmissible substrate 11, the recording layer 21, the reflective layer 22 and the protective layer 23 with the dummy substrate 12. The material for forming the adhesion layer 24 is not

particularly limited but it is preferable to form the adhesion layer 24 of ultraviolet ray curable adhesive agent.

[0036]

The optical recording medium 10 having the above described configuration can, for example, be fabricated in the following manner.

[0037]

The light transmissible substrate 11 having the grooves and the lands on the surface thereof is first fabricated by an injection molding process. Similarly, the dummy substrate 12 is fabricated by an injection molding process. It is unnecessary to form grooves and lands on the dummy substrate 12.

[0038]

Then, the recording layer 22 is formed on the surface of the light transmissible substrate 11 formed with the grooves and the lands. The recording layer 21 can be formed, for example, by applying a solvent containing an organic dye onto the light transmissible substrate 11 using a spin coating process and evaporating the solvent.

[0039]

Further, the reflective layer 22 is formed on the surface of the recording layer 21. The reflective layer 22 can be formed by a gas phase growth process using chemical species containing elements of the reflective layer 22. Illustrative examples of the gas phase growth process include vacuum deposition process, sputtering process and the like.

[0040]

Then, the protective layer 23 is formed on the surface of the reflective layer 22. The protective layer 23 can be formed, for example, by applying acrylic ultraviolet ray curable resin or epoxy ultraviolet ray curable resin whose viscosity is adjusted onto the reflective layer 22

using a spin coating process or the like to form a coating layer and projecting an ultraviolet ray onto the coating layer to cure it.

[0041]

Further, the adhesive layer 24 is formed on the surface of the protective layer 23. The adhesive layer 24 can be formed, for example, by applying ultraviolet ray curable resin whose viscosity has been adjusted onto the reflective layer 22 using a spin coating process or the like.

[0042]

Then, the multi-layered unit obtained by forming the recording layer 21, the reflective layer 22, the protective layer 23 and the adhesion layer 24 on the surface of the light transmissible substrate 11 is bonded onto the dummy substrate 12 via the adhesion layer 24 and the adhesion layer 24 is irradiated with an ultraviolet ray from the side of the dummy substrate 12, for example, thereby curing the adhesion layer 24 and reliably adhering the adhesion layer 24 and the dummy substrate 12.

[0043]

Here, it is not absolutely necessary to fabricate the optical recording medium 10 in the above described manner and the optical recording medium 10 can be fabricated using a known method.

[0044]

Next, a method for recording information in the optical recording medium 10 will be described below.

[0045]

When data are to be recorded in the optical recording medium 10, a laser beam whose power is modulated is projected onto the recording layer 21 of the optical recording medium 10 via the light incidence plane 11a while the optical recording medium 10 is being rotated, thereby decomposing and transforming the organic dye contained in a region of

the recording layer 21 onto which the laser beam is projected to form a recording mark. At this time, it is preferable to deform the light transmissible substrate 11 at a region corresponding to the region in which the organic dye is decomposed and transformed. It is necessary to set the power level of the laser beam to a level high enough for decomposing and transforming the organic dye contained in the recording layer 21 and it is necessary to set the power level of the laser beam to such a level that the organic dye contained in the recording layer 21 is not decomposed and transformed. Therefore, when data are to be recorded in the optical recording medium 10, the power level of the laser beam projected onto a region where a recording mark is to be formed is set to a recording power (*Pw*) and the power level of the laser beam projected onto a region where a blank region is to be formed is set to a bottom power (*Pb*).

[0046]

However, owing to heat transfer, however, the actual length of a recording mark (the length between the front edge portion of the recording mark and the rear edge portion thereof) formed in the recording layer 21 does not accurately correspond to the time period during which the laser beam whose power level was set to the recording power (*Pw*) was projected onto the recording layer 21. Therefore, when the power level of the laser beam is to be modulated, it is necessary to take into account not only the length of the recording mark to be formed but also the lengths of blank regions to be formed before and after the formation of the recording mark, the lengths of recording marks to be formed adjacently, the linear recording velocity and the like, and determine the time at which the power level of the laser beam is switched from the bottom power (*Pb*) to the recording power (*Pw*), namely,

a rise time of the power level of the laser beam and the time at which the power level of the laser beam is switched from the recording power (*Pw*) to the bottom power (*Pb*), namely, a fall time of the power level of the laser beam. Thus, a pulse pattern of the power level of the laser beam determined by taking into account not only the length of the recording mark to be formed but also the lengths of blank regions to be formed before and after the formation of the recording mark, the lengths of recording marks to be formed adjacently, the linear recording velocity and the like will be described below.

[0047]

Figure 2 is a diagram showing a pulse pattern of the power level of a laser beam to be projected for forming a recording mark in the optical recording medium 10 and the relationship between a data pulse to be recorded (RLL coded NRZI signal) and a pulse pattern of a power level of a laser beam is shown therein.

[0048]

As shown in Figure 2, when a recording mark is to be formed in the optical recording medium 10, the power level of the laser beam is modulated in accordance with a pulse wave having an amplitude between the bottom power (*Pb*) and the recording power (*Pw*). Here, as shown in Figure 2, a time t1 at which the power level of the laser beam is switched from the bottom power (*Pb*) to the recording power (*Pw*) is set so as to be delayed by a time period T1 with respect to the rising edge of a data pulse to be recorded, namely, a time t0 at which a data pulse rises and a time t3 at which the power level of the laser beam is switched from the recording power (*Pw*) to the bottom power (*Pb*) is set so as to be delayed (See Figure 2 (a)) or advanced (See Figure 2 (b)) by a time period T3 with respect to the falling edge of a data pulse to be recorded, namely,

a time t2 at which a data pulse falls. In the case where the time t3 at which the power level of the laser beam is switched from the recording power (*Pw*) to the bottom power (*Pb*) is delayed with respect to the falling edge of a data pulse to be recorded, namely, the time t2 as shown in Figure 2 (a), a value of the time period T3 is positive (plus) and on the other hand, in the case where the time t3 at which the power level of the laser beam is switched from the recording power (*Pw*) to the bottom power (*Pb*) is advanced with respect to the falling edge of a data pulse to be recorded, namely, the time t2 as shown in Figure 2 (b), the value of the time period T3 is negative (minus).

[0049]

Next, how the time period T1 is determined will be concretely described below. In this specification, the length of the time period T1 is expressed as T1 (*a*, *b*) where *a* is a length of a blank region to be formed immediately before a recording mark to be formed and *b* is a length of the recording mark to be formed. For example, when the length of a blank region to be formed immediately before a recording mark to be formed is 3T and the length of the recording mark to be formed is 4T, the length of the time period T1 is expressed as T1 (3T, 4T). As described above, in a DVD-R, the 8/16 modulation Code is employed as a data modulation code and each of the recording mark and the blank region is formed so as to have a length of any one of 3T to 11T and 14T.

[0050]

It is preferable for the time period T1 to satisfy one of two conditions described below and it is more preferable for the time period T1 to satisfy both of the two conditions.

[0051]

A first condition requires the time period T1 (*a*, *b*) to be set so that

in the case where *a1* is smaller than *a2*, T1 (*a1*, *b*) is longer than T1 (*a2*, *b*). This means that when a recording mark having a length *b* is to be formed, the time period T1 should be set longer as the length *a* of the blank region is shorter. However, it is not absolutely necessary to always set the time period T1 (*a*, *b*) so as to satisfy the formula: T1 (*a1*, *b*) > T1 (*a2*, *b*) in the case where *a1* is smaller than *a2* and it is sufficient to set the time period T1 (*a*, *b*) so as to satisfy the formula: T1 (*a1*, *b*) > T1 (*a2*, *b*) only when *a1* and *a2* have a particular relationship.

[0052]

It is preferable to set the time period T1 (*a*, *b*) so as to satisfy te formula: T1 (*a1*, *b*) > T1 (*a2*, *b*) because when data are to be recorded at a high linear recording velocity, a recording mark to be formed is liable to be influenced by heat generated in a recording layer by a laser beam projected for forming a preceding recording mark as the length of a blank region formed immediately before the recording mark, whereby the front edge portion of the recording mark is liable to be extended toward the preceding recording mark and the length of the recording mark becomes longer. This phenomenon of the front edge portion of the recording mark being extended toward the preceding recording mark and the length of the recording mark becoming longer becomes particularly prominent when the recording mark is formed after a blank region having the shortest length (3T in a DVD-R) but such a phenomenon is not substantially observed when the recording mark is formed after a blank region having a length longer than a predetermined length. For example, in the case of recording data in the recording layer 21 of the optical recording medium 10 at a 4 x speed of a DVD-R, namely, about 14 m/sec, the phenomenon of the front edge portion of the recording mark being extended toward the preceding recording mark and the length of the

recording mark becoming longer is not substantially observed when the recording mark is formed after a blank region having a length equal to or longer than 4T. Therefore, in the case of recording data in the recording layer 21 of the optical recording medium 10 at a high linear recording velocity such as 4 x speed, namely, about 14 m/sec, it is sufficient for the time period T1 when a recording mark is to be formed after a blank region having a length of 3T to be set so as to be longer than the time period T1 when a recording mark is to be formed after a blank region having a length of 4T and it is sufficient for the time period T1 when a recording mark is to be formed after a blank region having a length of any one of 4T to 11T and 14T to be set independently from the above mentioned first condition.

[0053]

A second condition requires the time period T1 (*a*, *b*) to be set so that in the case where *b1* is smaller than *b2*, T1 (*a*, *b1*) is shorter than T1 (*a*, *b2*). This means that when a blank region having a length *a* is to be formed prior to forming a recording mark, the time period T1 should be set longer as the length *b* of the recording mark is shorter. However, it is not absolutely necessary to always set the time period T1 (*a*, *b*) so as to satisfy the formula: T1 (*a*, *b1*) < T1 (*a*, *b2*) in the case where *b1* is smaller than *b2* and it is sufficient to set the time period T1 (*a*, *b*) so as to satisfy the formula: T1 (*a*, *b1*) < T1 (*a*, *b2*) only when *b1* and *b2* have a particular relationship.

[0054]

It is preferable to set the time period T1 (*a*, *b*) so as to satisfy the formula: T1 (*a*, *b1*) < T1 (*a*, *b2*) because when data are to be recorded at a high linear recording velocity, heat energy given by the laser beam becomes short as the length of a recording mark to be formed becomes

shorter, whereby the front edge portion of the recording mark is liable to be extended toward a following recording mark and the length of the recording mark becomes shorter. This phenomenon of the front edge portion of the recording mark being extended toward the following recording mark and the length of the recording mark becoming shorter becomes particularly prominent when the recording mark having the shortest length (3T in a DVD-R) is formed but such a phenomenon is not substantially observed when the length of the recording mark exceeds a predetermined length. For example, in the case of recording data in the recording layer 21 of the optical recording medium 10 at a 4 x speed of a DVD-R, namely, about 14 m/sec, the phenomenon of the front edge portion of the recording mark being extended toward the following recording mark and the length of the recording mark becoming shorter is not substantially observed when the recording mark having a length of 5T or longer is formed. Therefore, in the case of recording data in the recording layer 21 of the optical recording medium 10 at a high linear recording velocity such as 4 x speed, namely, about 14 m/sec, when a recording mark having a length of 3T or 4T is to be formed, the time period T1 is set so as to be shorter that the time period T1 when a recording mark having a length of 5T is to be formed and when a recording mark having a length of any one of 5T to 11T and 14T is to be formed, it is sufficient for the time period T1 to be set independently from the above mentioned second condition.

[0055]

In this embodiment, although it is not absolutely necessary for the time period T1 to be set so as to satisfy the above mentioned first and second conditions, it is preferable for the time period T1 to be set so as to satisfy one of the above mentioned first and second conditions and it is

more preferable for the time period T1 to be set so as to satisfy both of the above mentioned first and second conditions. In the case where the time period T1 is set in this manner, it is possible to suppress the offset of the front edge portion of a recording mark caused by recording data in an optical recording medium at a high linear recording velocity.

[0056]

Next, how the time period T3 is determined will be concretely described below. In this specification, the length of the time period T3 is expressed as T3 (x, y, z) where x is a length of a recording mark to be formed, y is a length of a blank region to be formed immediately after the formation of the recording mark and z is a length of a recording mark to be formed subsequent to the formation of the first mentioned recording mark. For example, when the length of the recording mark to be formed is 5T, the length of a blank region to be formed immediately after the formation of the recording mark is 6T and the length of the recording mark to be formed subsequent to the formation of the first mentioned recording mark is 7T, the length of the time period T3 is expressed as T3 (5T, 6T, 7T).

[0057]

In this embodiment, the time period T3 is set so as to satisfy at least one of the following conditions.

[0058]

A first condition requires the time period T3 (x, y, z) to be set so that in the case where $x1$ is smaller than $x2$, T3 ($x1$, y, z) is longer than T3 ($x2$, y, z). This means that in the case where the length y of a blank region to be formed immediately after the formation of the recording mark and the length z of a next recording mark are the same, the time period T3 should be set longer, in other words, the time period T2 should

be set longer as the length *x* of the recording mark is shorter. However, it is not absolutely necessary to always set the time period T3 (x, y, z) so as to satisfy the formula: T3 ($x1$, y, z) > T3 ($x2$, y, z) in the case where $x1$ is smaller than $x2$ and it is sufficient to set the time period T3 (x, y, z) so as to satisfy the formula: T3 ($x1$, y, z) > T3 ($x2$, y, z) only when $x1$ and $x2$ have a particular relationship.

[0059]

It is preferable to set the time period T3 (x, y, z) so as to satisfy the formula: T3 ($x1$, y, z) > T3 ($x2$, y, z) because when data are to be recorded at a high linear recording velocity, the phenomenon of the rear edge portion of the recording mark being extended toward the preceding recording mark and the length of the recording mark becoming shorter is observed and this phenomenon becomes prominent as the length *x* of a recording mark is shorter. This phenomenon of the rear edge portion of the recording mark being extended toward the preceding recording mark and the length of the recording mark becoming shorter becomes particularly prominent when the recording mark having the shortest length (3T in a DVD-R) is formed but such a phenomenon is not substantially observed when the length of the recording mark exceeds a predetermined length. For example, in the case of recording data in the recording layer 21 of the optical recording medium 10 at a 4 x speed of a DVD-R, namely, about 14 m/sec, the phenomenon of the rear edge portion of the recording mark being extended toward the preceding recording mark and the length of the recording mark becoming shorter is not substantially observed when the recording mark having a length of 4T or longer. Therefore, in the case of recording data in the recording layer 21 of the optical recording medium 10 at a high linear recording velocity such as 4 x speed, namely, about 14 m/sec, it is sufficient for the time

period T1 when a recording mark having a length of 3T is to be formed to be set so as to be shorter than the time period T1 when a recording mark having a length of 4T is to be formed and it is sufficient for the time period T1 when a recording mark having a length of any one of 4T to 11T and 14T is to be formed to be set independently from the above mentioned first condition.

[0060]

A second condition requires the time period T3 (x, y, z) to be set so that in the case where $y1$ is smaller than $y2$, T3 (x, $y1$, z) is longer than T3 (x, $y2$, z). This means that in the case where the length x of a recording mark to be formed and the length z of a next recording mark are the same, the time period T3 should be set longer, in other words, the time period T2 should be set longer as the length y of a blank region to be formed between the two recording marks is shorter. However, it is not absolutely necessary to always set the time period T3 (x, y, z) so as to satisfy the formula: T3 (x, $y1$, z) > T3 (x, $y2$, z) in the case where $y1$ is smaller than $y2$ and it is sufficient to set the time period T3 (x, y, z) so as to satisfy the formula: T3 (x, $y1$, z) > T3 (x, $y2$, z) only when $y1$ and $y2$ have a particular relationship.

[0061]

It is preferable to set the time period T3 (x, y, z) so as to satisfy the formula: T3 (x, $y1$, z) > T3 (x, $y2$, z) because the phenomenon of the rear edge portion of the recording mark being extended toward the preceding recording mark and the length of the recording mark becoming shorter becomes prominent as the length y of a blank region to be formed immediately after the formation of the recording mark is shorter. This phenomenon of the rear edge portion of the recording mark being extended toward the preceding recording mark and the length of the

recording mark becoming shorter becomes particularly prominent when the blank region to be formed immediately after the formation of the recording mark is the shortest blank region (3T in a DVD-R) but such a phenomenon is not substantially observed when the length of the blank region exceeds a predetermined length. For example, in the case of recording data in the recording layer 21 of the optical recording medium 10 at a 4 x speed of a DVD-R, namely, about 14 m/sec, the phenomenon of the rear edge portion of the recording mark being extended toward the preceding recording mark and the length of the recording mark becoming shorter is not substantially observed when the length of a blank region to be formed immediately after the formation of the recording mark is 4T or longer. Therefore, it is sufficient for the time period T3 when the length of a blank region to be formed immediately after the formation of the recording mark is 3T to be set so as to be shorter than the time period T3 when the length of a blank region to be formed immediately after the formation of the recording mark is 4T and it is sufficient for the time period T3 when the length of a blank region to be formed immediately after the formation of the recording mark is any one of 4T to 11T and 14T to be set independently from the above mentioned second condition.

[0062]

A third condition requires the time period T3 (x, y, z) to be set so that in the case where $z1$ is smaller than $z2$, T3 (x, y, $z1$) is longer than T3 (x, y, $z2$). This means that in the case where the length x of a recording mark to be formed and the length y of a blank region to be formed after the formation of the recording mark are the same, the time period T3 should be set longer, in other words, the time period T2 should be set longer as the length z of a next recording mark is shorter. However, it is not absolutely necessary to always set the time period T3 (x, y, z) so

as to satisfy the formula: T3 (x, y, $z1$) > T3 (x, y, $z2$) in the case where $z1$ is smaller than $z2$ and it is sufficient to set the time period T3 (x, y, z) so as to satisfy the formula: T3 (x, y, $z1$) > T3 (x, y, $z2$) only when $z1$ and $z2$ have a particular relationship.

[0063]

It is preferable to set the time period T3 (x, y, z) so as to satisfy the formula: T3 (x, y, $z1$) > T3 (x, y, $z2$) because the phenomenon of the rear edge portion of the recording mark being extended toward the preceding recording mark and the length of the recording mark becoming shorter becomes prominent as the length z of a next recording mark is shorter. This phenomenon of the rear edge portion of the recording mark being extended toward the preceding recording mark and the length of the recording mark becoming shorter becomes particularly prominent when the next recording mark is the shortest blank region (3T in a DVD-R) but such a phenomenon is not substantially observed when the length of the next recording mark exceeds a predetermined length. For example, in the case of recording data in the recording layer 21 of the optical recording medium 10 at a 4 x speed of a DVD-R, the phenomenon of the rear edge portion of the recording mark being extended toward the preceding recording mark and the length of the recording mark becoming shorter is not substantially observed when the length of a next recording mark is 4T or longer. Therefore, it is sufficient for the time period T3 when the length of a next recording mark is 3T to be set so as to be shorter than the time period T3 when the length of a next recording mark is 4T and it is sufficient for the time period T3 when the length of a blank region to be formed immediately after the formation of the recording mark is any one of 4T to 11T and 14T to be set independently from the above mentioned third condition.

[0064]

It this embodiment, it is sufficient for the time period T3 to be set so as to satisfy at least one of the above mentioned first to third conditions. However, it is preferable for the time period T3 to be set so as to satisfy two or more of the above mentioned first to third conditions and it is most preferable for the time period T3 to be set so as to satisfy all of the above mentioned first to third conditions. Thus, in the case where data are to be recorded in an optical recording medium of a DVD-R type at a 4 x speed of a DVD-R, namely, about 14 m/sec, it is particularly preferable for the time period T3 (*x*, *y*, *z*) to be set so as to satisfy the following formulae.

T3 (3, 3, 3) > T3 (4 or more, 3, 3),

T3 (3, 3, 3) > T3 (3, 4 or more, 3) and

T3 (3, 3, 3) > T3 (3, 3, 4 or more)

[0065]

The reason why it is preferable to set the time period T3 so as to satisfy the above mentioned first to third conditions will be described below.

[0066]

In the case where data are to be recorded in a write-once type optical recording medium including a recording layer containing an organic dye, as a length *x* of a recording mark is shorter, the rear edge portion of the recording mark is extended toward the preceding recording mark and the length of the recording mark becomes shorter. This means that the length of a blank region to be formed immediately after the formation of the recording mark becomes longer than a predetermined length. Such a phenomenon becomes particularly prominent in the case where the recording mark is the shortest recording mark. For example,

when data are to be recorded in a DVD-R at about a 4 x speed of a DVD-R, namely, about 14 m/sec, a recording mark having a length shorter than 3T, for example, about 2.5T is formed. In the case where such a recording mark is formed, distortion (so-called 2.5T distortion) is generated in a signal obtained by reproducing data.

[0067]

In a study done by the inventors of the present invention, it was found that the phenomenon of the length of a recording mark becoming shorter became prominent as the length y of a blank region to be formed immediately after the formation of the recording mark became shorter and the length z of a net recording mark became shorter.

[0068]

Here, it is reasonable to conclude that the phenomenon of the length of a recording mark becoming shorter becomes prominent as the length x of the recording mark is shorter, because energy of a laser beam applied to the recording mark becomes short as the length of the recording mark is shorter, whereby the rear edge portion of the recording mark is liable to be extended toward the preceding recording mark.

[0069]

Further, it is reasonable to conclude that the phenomenon of the length of a recording mark becoming shorter becomes prominent as the length y of a blank region to be formed immediately after the formation of the recording mark is shorter, because the influence of heat generated by irradiation with the laser beam for forming a next recording mark on the recording mark becomes larger as the length of a blank region to be formed immediately after the formation of the recording mark is shorter and the deformation of the light transmissible substrate 11 at the rear edge portion of the recording mark is prevented by the influence of heat,

whereby the rear edge portion of the recording mark is extended toward the preceding recording mark and the length of the recording mark becomes shorter.

[0070]

Furthermore, it is reasonable to conclude that the phenomenon of the length of a recording mark becoming shorter becomes prominent as the length z of a next recording mark is shorter, because as described with respect to the second condition for setting the time period T1, it is preferable to set the time period T1 to be shorter as the length of the recording mark is shorter and the rise time of the power level of the laser beam to be projected for forming a next recording mark is advanced as the length of the next recording mark is shorter. In other words, in the case where the rise time of the power level of the laser beam to be projected for forming a next recording mark is advanced, the influence of heat caused by the rising of the laser beam power level on the rear edge portion of the recording mark is increased and as a result, the deformation of the light transmissible substrate 11 is prevented, whereby the rear edge portion of the recording mark is extended toward the preceding recording mark and the length of the recording mark becomes shorter.

[0071]

Therefore, the phenomenon of the length of a recording mark becoming shorter becomes particularly prominent in the case where a recording mark is the shortest recording mark, a blank region to be formed immediately after the formation of the recording mark is the shortest blank region and the next recording mark is the shortest recording mark. Thus, in the case where data are to be recorded in an optical recording medium of a DVD-R type at a 4 x speed of a DVD-R,

namely, about 14 m/sec, if the time period T3 (x, y, z) is set so as to satisfy the following formulae, it is possible to effectively prevent a 3T mark which is the shortest recording mark in a DVD-R from being shortened and it is possible to reduce the distortion of a reproduced signal.

[0072]

Further, since the phenomenon of the rear edge portion of a short recording mark being extended toward the preceding recording mark and the length of the recording mark becoming shorter becomes prominent as a linear recording velocity becomes higher, in the case where T3'(x, y, z : VL) is a value obtained by normalizing the time period T3 at a linear recording velocity VL with a channel bit period and T3'(x, y, z : VH) is a value obtained by normalizing the time period T3 at a linear recording velocity VH higher than the linear recording velocity VL with the channel bit period, it is preferable to set T3'(x, y, z : VL) and T3'(x, y, z : VH) so as to satisfy the formula: T3'(x, y, z : VL) < T3'(x, y, z : VH). This means that in the case where the length x of a recording mark, the length y of a blank region to be formed immediately after the formation of the recording mark and the length z of a next recording mark are the same, a value obtained by normalizing the time period T3 with the channel bit period should be set to be loner as a linear recording velocity is higher. Therefore, in a DVD-R in which each of the shortest recording mark and the shortest blank region is 3T, it is particularly preferable to set a value T3' obtained by normalizing the time period T3 with the channel bit period so as to satisfy the formula: T3'(3, 3, 3 : VL) < T3'(3, 3, 3 : VH).

[0073]

The concrete pulse pattern for forming a recording mark in the

optical recording medium 10 has been described above.

[0074]

As described above, the pulse pattern for forming a recording mark in the optical recording medium 10 is determined by taking into account not only heat generated by irradiation with a laser beam for forming a target recording mark but also the influence of heat generated by irradiation with a laser beam for forming preceding and following recording marks, it is possible to form a recording mark and a blank region so as to have a desired length. Therefore, when data are recorded in the optical recording medium 10 in accordance with the information recording method according to the present invention, it is possible to obtain a signal having good signal characteristics by reproducing data recorded in the optical recording medium 10. Here, since the offsets of the front edge portion and the rear edge portion of a recording mark becomes large as a linear recording velocity is higher, the information recording method according to the present invention is particularly effective in the case of recording data at a high linear recording velocity.

[0075]

It is preferable for information for identifying the pulse pattern described above to be stored in the optical recording medium 10 as "recording condition setting information." In the case where such recording condition setting information is stored in the optical recording medium 10, when data are to be recorded by a user, the recording condition setting information is read by an information recording apparatus, whereby a pulse pattern can be determined based on the thus read recording condition setting information.

[0076]

It is more preferable for the recording condition setting

information to include not only the pulse pattern but also information necessary for identifying various conditions such as a linear recording velocity necessary for recording data in the optical recording medium 10. The recording condition setting information may be stored in the optical recording medium 10 in the form of wobbles or pre-pits or may be recorded as data in the recording layer 21. it is not absolutely necessary for the recording condition setting information to be constituted so as to directly indicate conditions necessary for recording data but may be constituted so as to specify one of conditions stored in an information recording apparatus in advance, thereby indirectly identifying recording conditions such as a pulse pattern.

[0077]

Next, an information recording apparatus for recording data in the optical recording medium 10 will be described below.

[0078]

Figure 3 is a diagram schematically showing a main portion of an information recording apparatus 50 which can record data in an optical recording medium 10.

[0079]

As shown in Figure 3, the information recording apparatus 50 includes a spindle motor 52 for rotating the optical recording medium 10, a head 53 for projecting a laser beam onto the optical recording medium 10 and receiving the light reflected by the optical recording medium 10, a controller 54 for controlling the operation of the spindle motor 52 and the head 53, a laser driving circuit 55 for feeding a laser drive signal to the head 53, and a lens driving circuit 56 for feeding a lens drive signal to the optical head 53.

[0080]

Further, as shown in Figure 3, the controller 54 includes a focus servo tracking circuit 57, a tracking servo circuit 58 and a laser control circuit 59. When the focus servo tracking circuit 57 is activated, a laser beam is focused onto the recording surface of the rotating optical recording medium 10 and when the tracking servo circuit 58 is activated, the spot of the laser beam automatically follows the track of the optical recording medium 10. Each of the focus servo tracking circuit 57 and the tracking servo circuit 58 has an auto-gain control function for automatically adjusting the focus gain and an auto-gain control function for automatically adjusting the tracking gain. Further, the laser control circuit 59 is adapted to generate a laser drive signal to be supplied by the laser drive circuit 55 based on the recording condition setting information recorded in the optical recording medium 10.

[0081]

Here, it is not absolutely necessary for the focus servo tracking circuit 57, the tracking servo circuit 58 and the laser control circuit 59 to be built in the control circuit 54 and each of them may be separately constituted from the control circuit 54. Further, it is not necessary for each of the focus servo tracking circuit 57, the tracking servo circuit 58 and the laser control circuit 59 to be constituted as a physical circuit but the function of each of them may be achieved by software.

[0082]

In the case where data are to be recording in the optical recording medium 10 using the thus constituted information recording apparatus 50, the recording condition setting information recorded in the optical recording medium 10 in the above described manner is read, thereby determining a pulse pattern. Therefore, since it is possible to form a recording mark and a blank region so as to have a desired length, a

signal having good signal characteristics can be obtained by reproducing data recorded in the optical recording medium 10.

[0083]

The present invention has thus been shown and described with reference to a specific embodiment. However, it should be noted that the present invention is in no way limited to the details of the described arrangements but changes and modifications may be made without departing from the scope of the appended claims.

[0084]

For example, in the above described embodiment, although the explanation was made as to the case of recording data in a write-once type optical recording medium 10 of a DVD-R type, the present invention can be widely applied to not only the case of recording data in a write-once type optical recording medium 10 of a DVD-R type but also the cases of recording data in other write-once type optical recording media such as a write-once type optical recording medium of a CD-R type, a next-generation type optical recording medium having a very thin light transmission layer. Furthermore, the present invention can be applied to a write-once type optical recording medium including a recording layer constituted by a laminated body of a plurality of inorganic reaction films.

[0085]

[TECHNICAL ADVANTAGE OF THE INVENTION]

As described above, according to the present invention, since a pulse pattern of the power level of the laser beam to be projected for forming a recording mark in the optical recording medium 10 is determined by taking into account not only heat generated by irradiation with a laser beam for forming a target recording mark but also the influence of heat generated by irradiation with a laser beam for forming

a preceding recording mark and a subsequent recording mark, even in the case where data are to be recorded in the optical recording medium 10 at a high linear recording velocity, it is possible to form a recording mark and a blank region so as to have a desired length. Therefore, a signal having good signal characteristics can be obtained by reproducing data recorded in the optical recording medium 10.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[Figure 1]

Figure 1 (a) is a schematic partially cutaway perspective view showing an optical recording medium 10 to which an information recording method according to the present invention can be preferably applied and Figure 1 (b) is an enlarged cross-sectional view showing a section indicated by the symbol A in Figure 1 (a).

[Figure 2]

Figure 2 is a diagram showing a pulse pattern for forming a recording mark in an optical recording medium 10.

[Figure 3]

Figure 3 is a diagram schematically showing a main portion of an information recording apparatus 50 which can record data in an optical recording medium 10.

[BRIEF DESCRIPTION OF REFERENCE NUMERALS]

11 ..... a light transmissible substrate

12 ..... a dummy substrate

21 ..... a recording layer

22 ..... a reflective layer

23 ..... a protective layer

24 ..... an adhesive layer

50 ..... an information recording apparatus

52 ..... a spindle motor

53 ..... a head

54 ..... a controller

55 ..... a laser driving circuit

56 ..... a lens driving circuit

57 ..... a focus servo tracking circuit

58 ..... a tracking servo circuit

59 ..... a laser control circuit

[Name of Document] ABSTRACT OF THE DISCLOSURE

[Abstract]

[Problems]

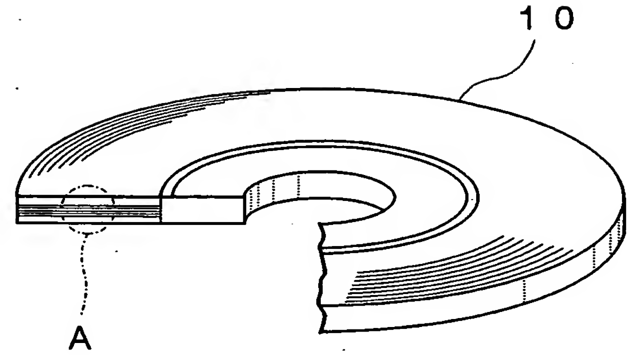
It is an object of the present invention is to provide an information recording method which is suitable for recording data in a write-once type optical recording medium at a high linear recording velocity.

[Solutions]

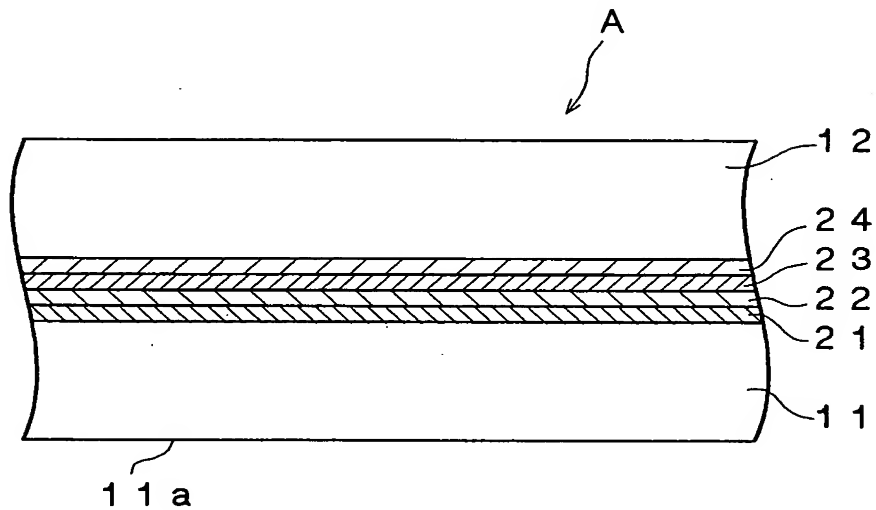
In an information recording method for recording data in a write-once type optical recording medium according to the present invention, a pulse pattern of the power level of a laser beam to be projected for forming a first recording mark is determined based on at least one of a length of a blank region to be formed immediately after the formation of the first recording mark and a length of a second recording mark to be formed subsequent to the formation of the first recording mark. According to the present invention, since it is possible to optimize the pulse pattern of the power level of a laser beam to be projected for forming a first recording mark by taking into account the length of a blank region to be formed immediately after the formation of the first recording mark and the length of a second recording mark to be formed subsequent to the formation of the first recording mark, even in the case where data are to be recorded in the optical recording medium 10 at a high linear recording velocity, a signal having good signal characteristics can be obtained by reproducing data recorded in the optical recording medium 10.

[Selected Figure] Figure 2

FIG. 1

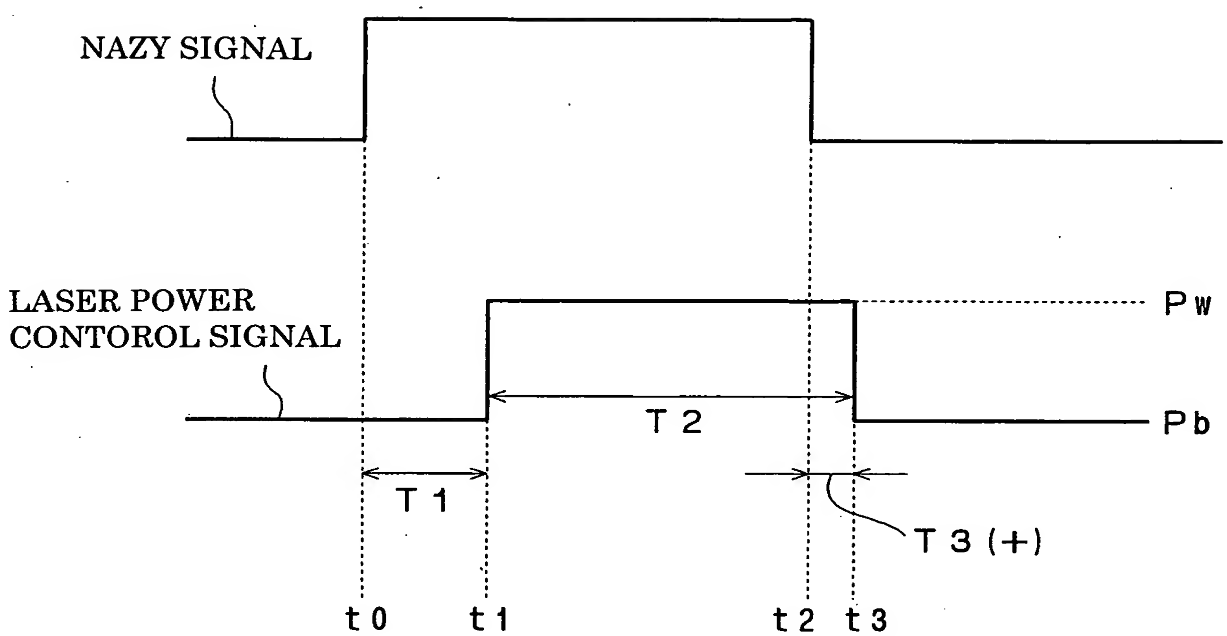


(a)



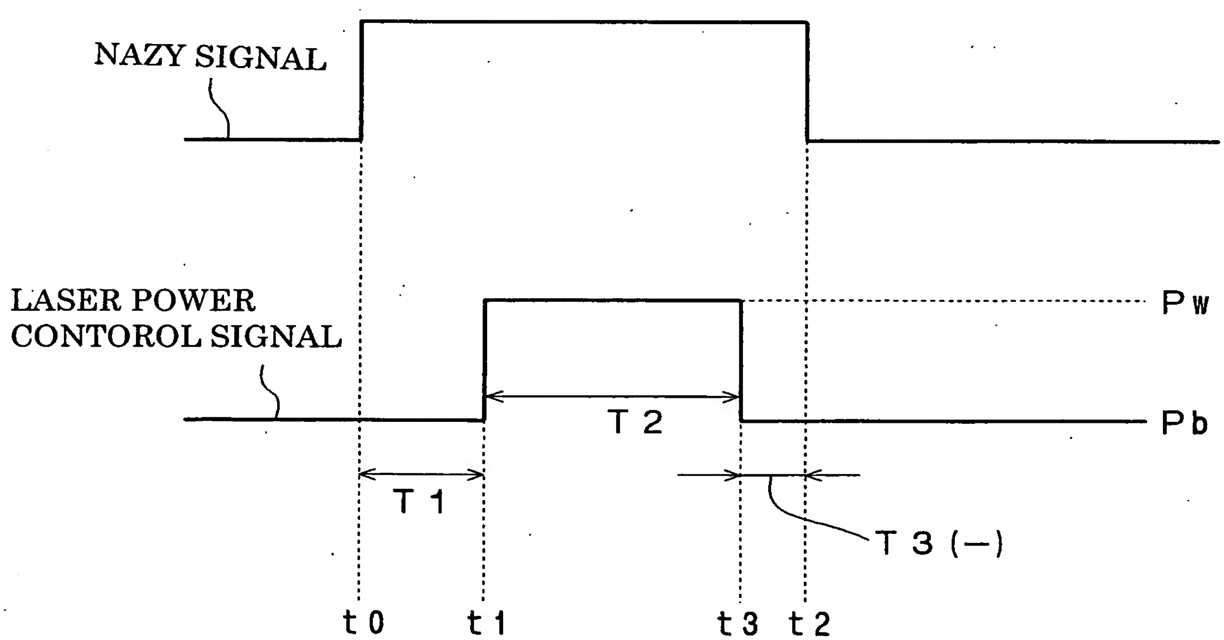
(b)

FIG. 2



NAZY SIGNAL
LASER POWER
CONTOROL SIGNAL
Pw
Pb
T 2
T 1
T 3 (+)
t 0
t 1
t 2
t 3

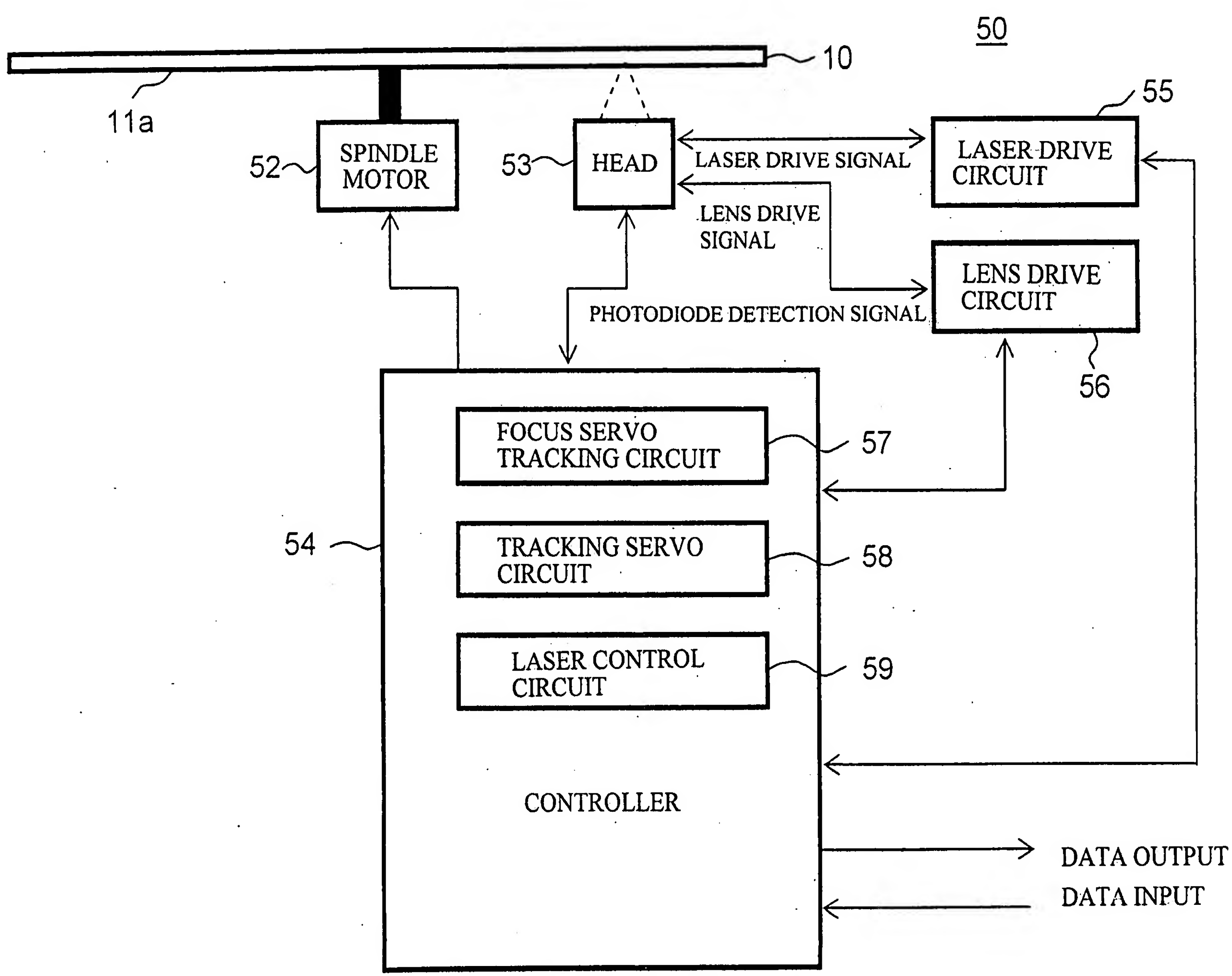
(a)



NAZY SIGNAL
LASER POWER
CONTOROL SIGNAL
Pw
Pb
T 2
T 1
T 3 (−)
t 0
t 1
t 3
t 2

(b)

FIG. 3


50
10
11a
55
52
SPINDLE MOTOR
53
HEAD
LASER DRIVE SIGNAL
LASER-DRIVE CIRCUIT
LENS DRIVE SIGNAL
LENS DRIVE CIRCUIT
PHOTODIODE DETECTION SIGNAL
56
FOCUS SERVO TRACKING CIRCUIT
57
54
TRACKING SERVO CIRCUIT
58
LASER CONTROL CIRCUIT
59
CONTROLLER
DATA OUTPUT
DATA INPUT